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EFFECT OF IRRIGATION REGIMES AND NITROGEN SOURCES ON NITROGEN UPTAKE BY WHEAT

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A field experiment was conducted at the National Agricultural Research Centre to find out the most efficient source of N for wheat under different irrigation regimes. Ammonium nitrate, sulphur-coated urea and prilled urea were applied @ 150 kg N ha^{-1}. Irrigations were applied at 25% less than ET, equal to ET and at 50% more of ET. Ammonium nitrate and SCU were proved better than urea for grain and straw yields, N uptake, N recovery and agronomic efficiency. The irrigation regime of I_2 was the best treatment. No NO_3-N leaching losses were evident under I_1 and I_2 irrigation treatments, but the chances of leaching were more under I_3 treatment.

INTRODUCTION

The applied nitrogen in the form of chemical fertilizers may lost from the soil-plant system through runoff, denitrification, leaching and volatilization (Miller and Wolf, 1987). Efficient fertilizer practices aim at maximizing the use of applied fertilizer by the crop in the most economical way for optimum crop production.

The uptake and loss of applied N through leaching depends upon the amount of water applied through irrigation, as excessive water application causes leaching of N in the form of nitrates (Bauder and Schneider, 1979). On the other hand, due to low moisture contents in arid and semi-arid regions, NO_3-N leaching beyond the root zone is believed to be negligible rather accumulates in the surface layers (Benbi and Singh, 1988). The mass of NO_3-N leached is directly related to the drainage volume. By increasing irrigation efficiencies, both the drainage volume and the amount of NO_3-N can be reduced (William *et al.*, 1985).

Different N sources behave differently in terms of grain yield, N uptake and NO_3-N concentraion in the soil profile. The NO_3-N concentration of the soil profile was higher when ammonium nitrate was applied than where other N sources were used (Pleysier *et al.*, 1987). Mineralization of slow-release N sources such as sulphur coated urea, ensures the regulated supply of N to the crop over a long spell of time, and hence proved better than urea (Joshi *et al.*, 1986). They have also reported that NO_3-N content of the soil treated with SCU after the crop harvest, was lower than in soil treated with urea. The aim of this study was to test different N sources for wheat under different irrigation regimes, to determine their effect on yield, N recovery, contribution towards NO_3-N concentration in the soil profile and NO_3-N leaching during the crop growing season.

MATERIALS AND METHODS

The experiment was conducted in the field (Table 1) under randomised complete block design with four replications. Wheat variety Pak 81 was sown, and three N sources, ammonium nitrate, urea and

Table 1. Physical and chemical analysis of the soil, rainfall received during the season and delta of irrigation applied on wheat

Parameters	Reading	Rainfall (mm)	ET ($mm\ day^{-1}$)	Delta of irrigation (cm)	
				Rate (cm)	Total
Soil textural class	Sandy clay loam	Oct. (25.40) Nov. (0.00) Dec. (5.90)	3.40 1.50 1.10	I_1 (5.63) I_2 (7.50) I_3 (11.25)	11.3* 15.0 22.5
pHs	7.86				
Ec_e ($dS\ m^{-1}$)	1.10	Jan. (6.00)	1.00		
Organic matter (%)	0.60	Feb. (1.56)	1.80		
Total N (%)	0.04	March (30.40)	3.00		
NO_3-N (ppm)	4.10	April (16.24)	5.10		
NH_4-N (ppm)	0.98	May (10.24)	6.20		
AB-DTPA Ext. P (ppm)	4.56				
Amm. acetate Ext. K (ppm)	112.00				

* = Number of irrigations

sulphur-coated urea were applied @ 150 kg N ha^{-1}. The irrigations were: I_1 = 25% less than ET; I_2 = ET and I_3 = 50% more than ET. Standard Evapotranspiration (ET) value used for calculating irrigation regimes was 7.5 cm. The plot size was 22.5 m^2 for fertilizer treatments and 110 m^2 for irrigation treatments. The irrigation water requirement in terms of time to be applied to each plot was calculated according to the formula:

$$T = \frac{a \times d}{q}$$

where

T = Time in seconds; a = area in meter squares or m^2, d = depth of applied water (cm) and q = discharge from the cut throat flume ($cm3\ sec^{-1}$) = ($L \times 1,000$) sec^{-1}.

Grain and straw yields were recorded by harvesting 2 x 2 m from each sub-plot.

The grain and straw samples were collected for total N analysis, on the basis of which N uptake and N recovery were calculated according to the formulae:

N uptake (kg) = N uptake by grain + N uptake by straw

$$\text{Nitrogen recovery (\%)} = \frac{NF - NC}{\text{N applied}} \times 100$$

where

NF = N uptake from fertilized plots and
NC = N uptake from control plots

The soil samples were collected from 0-15, 15-30, 30-60, 60-90 and 90-120 cm soil depth after crop harvesting, for the NO_3-N analysis by AB-DTPA method (Soltanpour and Workman, 1979). The data were analysed statistically by using randomised complete block (two factorial) design.

RESULTS AND DISCUSSION

Agronomic data from the experiment show that grain and straw yields were increased significantly with the application of N fertilizer regardless of the sources (Table 2). These results agree with those of Parsad *et al.* (1981). The interaction of

Table 2. Effect of water regimes and nitrogen sources on grain and straw yields, N uptake and N recovery and agronomic efficiency

Treatment*		Grain yield (Tons ha^{-1})	Straw yield (Tons ha^{-1})	N uptake (kg ha^{-1})	N recovery (%)	Agronomic efficiency (kg grain kg^{-1} N)
Control	I1	2.15 F	2.78 H	33.60 E	-	-
A/N	I1	3.46 D	4.58 E	81.40 CD	31.90 CDE	8.72 CD
Urea	I1	3.30 E	4.39 F	76.30 D	28.47 E	7.65 E
SCU	I1	3.45 CD	4.66 DE	84.00 BC	33.60 BCD	8.65 CD
Control	I2	2.19 F	3.06 G	35.80 E	-	-
A/N	I2	3.97 A	5.44 A	102.10 A	44.22 A	11.88 A
Urea	I2	3.72 B	4.95 B	89.50 B	35.80 B	10.23 B
SCU	I2	4.03 A	5.57 A	100.50 A	43.12 A	12.22 A
Control	I3	2.15 F	2.84 H	34.60 E	-	-
A/N	I3	3.51 CD	4.76 CD	88.00 BC	35.54 BC	9.05 C
Urea	I3	3.39 DE	4.58 E	80.90 CD	30.83 DE	8.28 DE
SCU	I3	3.55 C	4.83 BC	89.30 B	36.45 B	9.32 C

* Nitrogen was applied @ 150 kg N ha^{-1}.
Means in a column followed by different letters are significantly different at 1% probablity.

fertilizer application and irrigation was significant. Maximum grain yield was produced in sulphur coated urea treated plots, followed by ammonium nitrate under irrigation regime of I_2 but the difference between these two was not significant.

The irrigation regimes significantly affected grain yield. Maximum grain yield of 3.47 tons ha^{-1} was obtained with the application of water according to the I_2 irrigation regime. This was significantly higher than the yields for I_1 and I_3 (William

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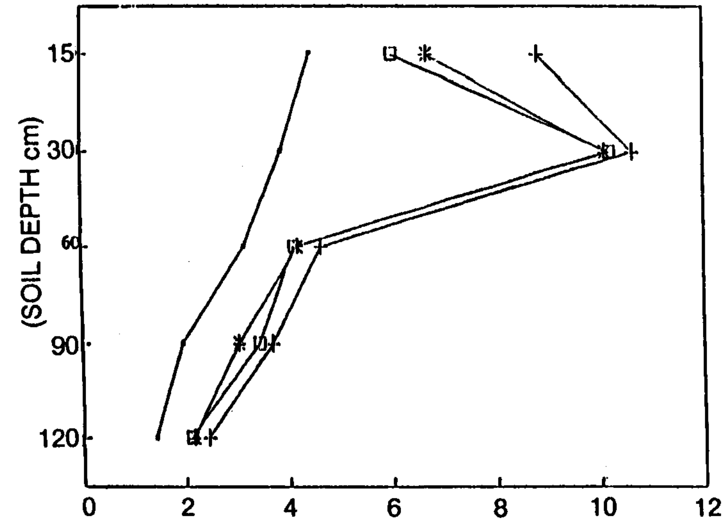

12 (NO_3-N ppm)

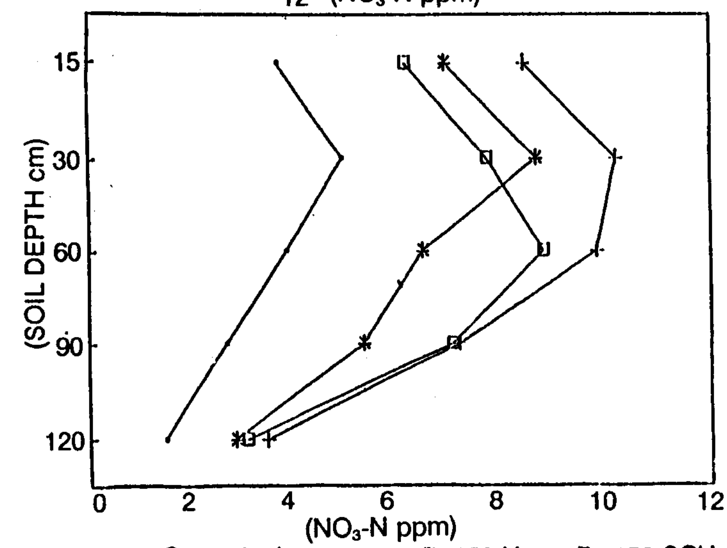

Fig. 1 & 2. Nitrate nitrogen contents of soil profile after wheat 1988-89 under irrigation regimes of I_1 and I_2.

et al., 1985). The difference between ammonium nitrate and sulphur coated urea was non-significant but both were superior to urea irrespective of the irrigation level. Pleysier *et al.* (1987) have proved that ammonium nitrate was superior to urea. Joshi *et al.* (1986) showed that slow releasing nitrogen fertilizer (SCU) was better than urea, as SCU ensures the regulated supply to crop throughout the growing season. Almost similar trend was observed regarding the straw yield (Table 2).

urea. The interaction of irrigation and fertilizer sources was found to be significant. Nitrogen uptake was significantly higher under I_2 than with I_1 and I_3 regimes. Increase in grain yield may be attributed to increased nitrogen uptake and recovery from the applied N fertilizer (Olson and Swallon, 1984). The lower nitrogen uptake under I_1 can be attributed to restricted movement of nitrogen towards plant roots, due to less moisture. On the other hand, heavy irrigations (I_3) caused the downward

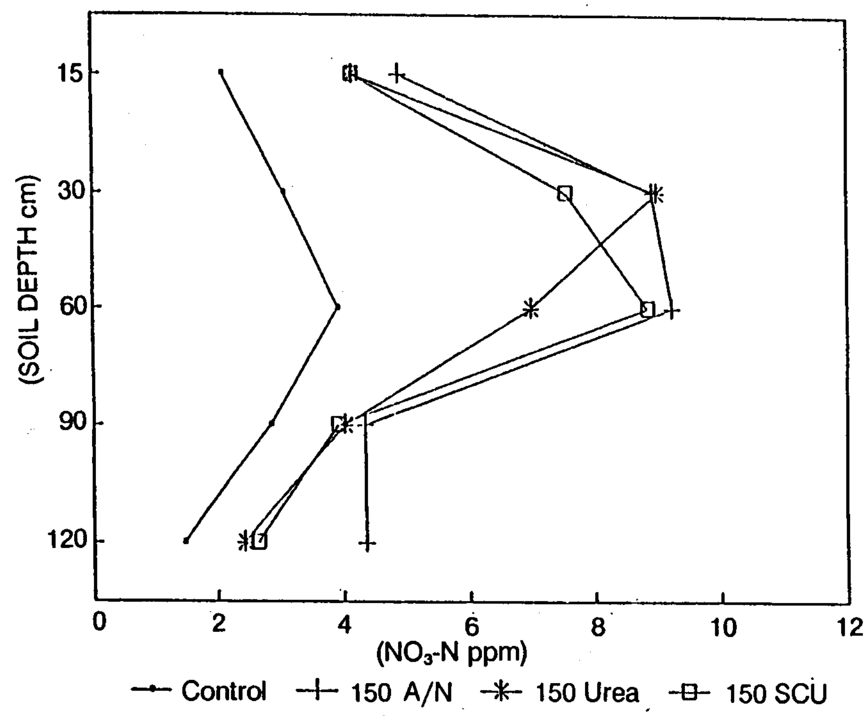

Fig. 3. Nitrate nitrogen contents of soil profile after wheat 1988-89 under irrigation regime of I_3.

Nitrogen uptake was maximum in ammonium nitrate treated plots, followed by sulphur coated urea treated ones under irrigation treatment of I_2 (Table 2). The difference between these two fertilizers was non-significant, but both were superior to

movement of highly soluble NO_3-N to deeper soil layers which might not be available to the plant (Bauder and Schneider, 1979).

Maximum recovery of the applied nitrogen (Table 2) was observed from ammonium nitrate and sulphur coated urea with non-significant differences, but the recovery from urea was significantly lower than those under I_2. Comparing the irrigation treatment, I_2 with 41.05% recovered N, proved better than I_1 (31.32%). The difference between I_2 and I_3 was not significant.

Sulphur coated urea along with optimum amount of water, produced more wheat kg^{-1} of applied N (12.22 kg grain kg^{-1} N applied) than with either ammonium nitrate (11.88 kg grain kg^{-1} N applied) or urea (10.23 kg grain kg^{-1} N applied). The difference between SCU and A/N was non-significant, but both were significantly superior to urea.

The NO_3-N contents of the soil profile were increased with the application of N fertilizer, irrespective of the nitrogen source (Fig. 1 & 2). Pleysier *et al.* (1987) have reported an increase in NO_3-N contents in the soil profile after N fertilizer application. Maximum NO_3-N was found in ammonium nitrate treated plots and higher than those of sulphur coated urea and urea treated plots almost at all the soil depths under all the irrigation regimes. Joshi *et al.* (1986) have reported the similar results. Nitrate nitrogen movement in the soil is closely related to water movement in soil. The NO_3-N was moved to deeper layers of soil (90-120 cm) under irrigation treatment of I_3. The displacement of NO_3-N from upper layers (0-15 and 15-30 cm) to lower layers (30-60 and 60-90 cm) was also observed under I_2, but it remained within the effective root zone, and is believed to be utilised by the crop roots (William *et al.*, 1985). Under irrigation treatment I_1, The NO_3-N accumulated in the upper layers. There was no evidence of net NO_3-N leaching loss from I_1 and I_2, as the NO_3-N contents of the lower layers of soil (90-120 cm) were almost equal to the control treatment (Benbi and Singh, 1988).

This test indicated that ammonium nitrate and sulphur coated urea are better N sources than urea under irrigated conditions. The NO_3-N leaching chances are minimum, if the irrigation is applied in accordance with the daily evapotranspiration (ET) requirement of the respective crop.

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